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(54) **LIQUID LEVEL TRANSDUCER WITH ISOLATED SENSOR**

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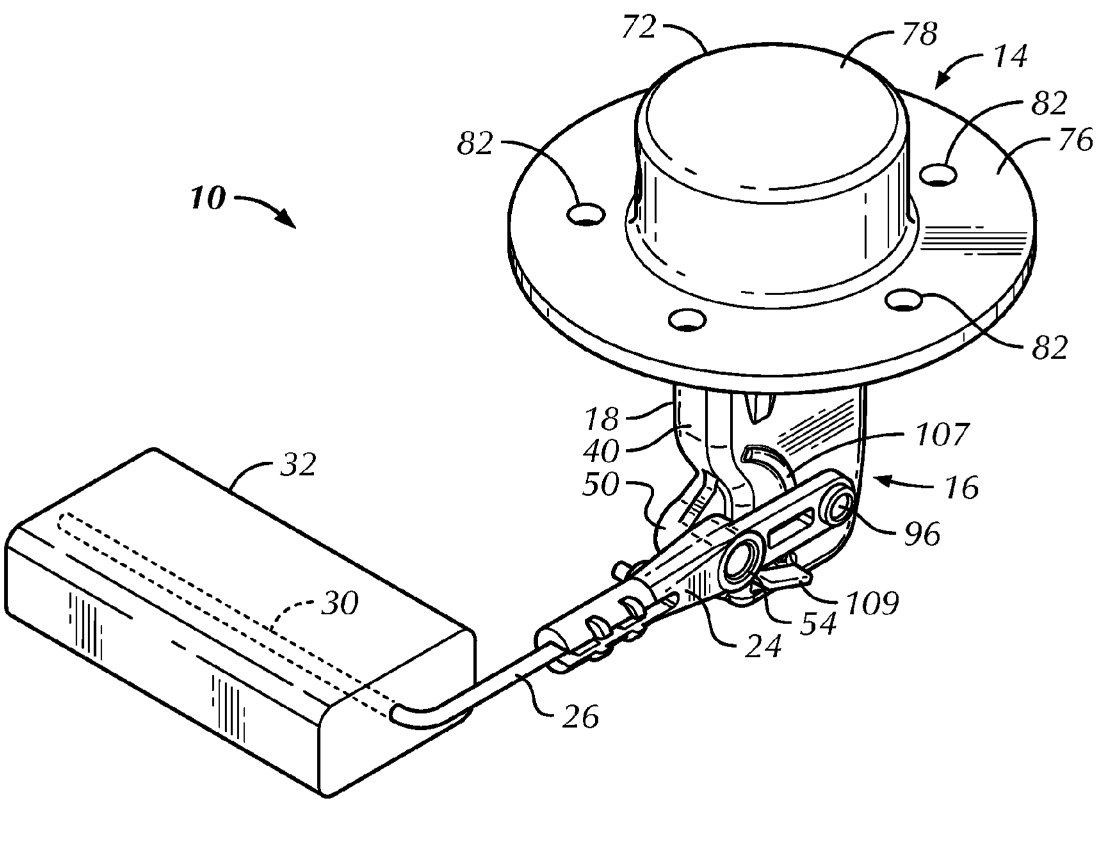
USPC **73/313**

(57) **ABSTRACT**

A transducer for determining the level of liquid within a container includes a mounting head adapted for connection to the container and a sensor assembly adapted to extend into the container from the mounting head. The sensor assembly includes a housing having an upper portion connected to the mounting head and a lower portion that extends from the upper portion. The lower portion has a hollow interior that is isolated from liquid within the container. At least one sensor element is located within the hollow interior. A float rod is pivotally connected to the housing and rotates in response to a change in liquid level within the container. An actuator located outside of the housing is connected to the float rod and is operative to change an electrical state of the at least one sensor element to thereby indicate a level condition of the liquid within the container.



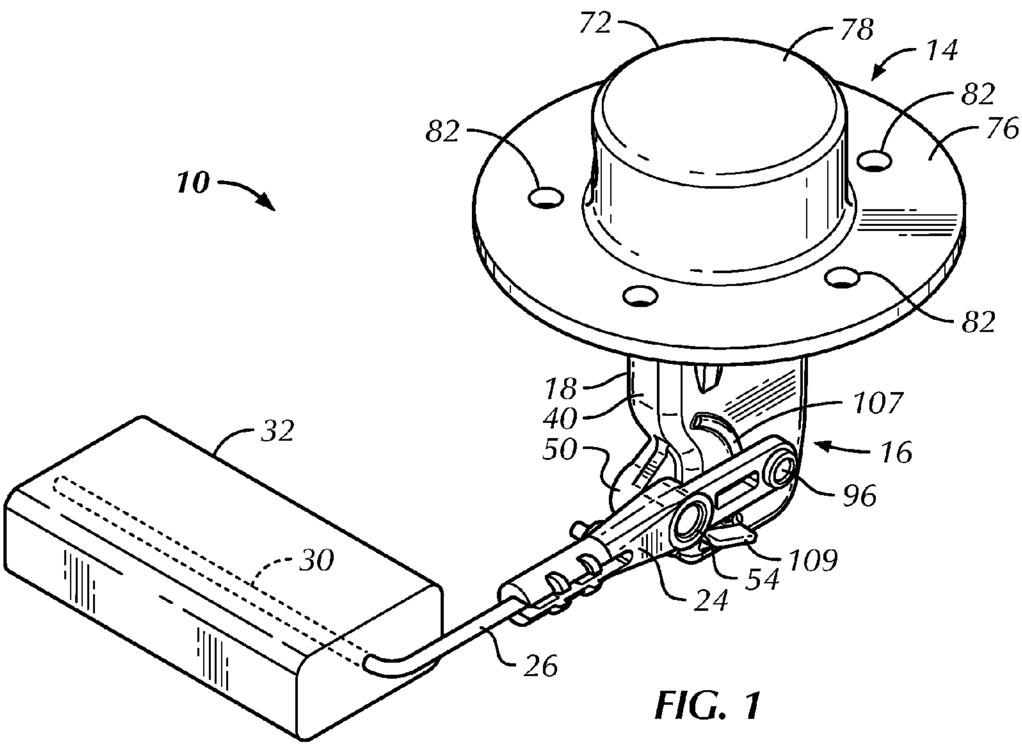


FIG. 1

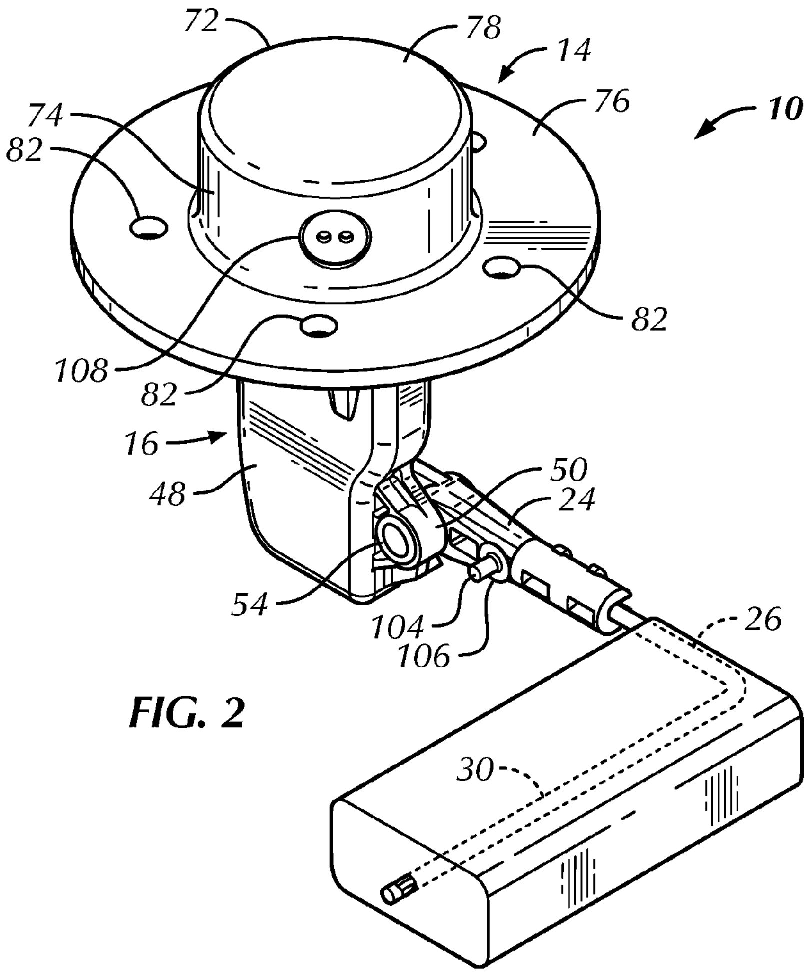


FIG. 2

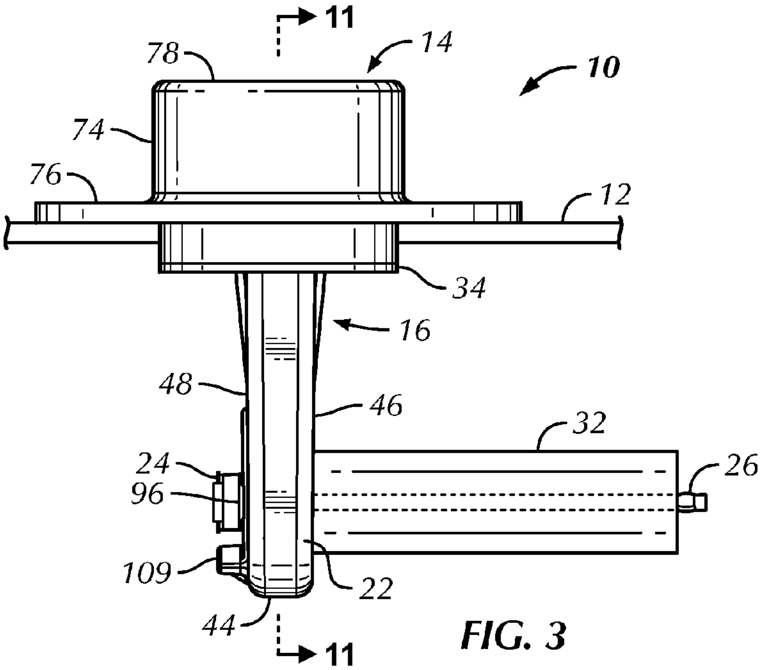

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FIG. 3

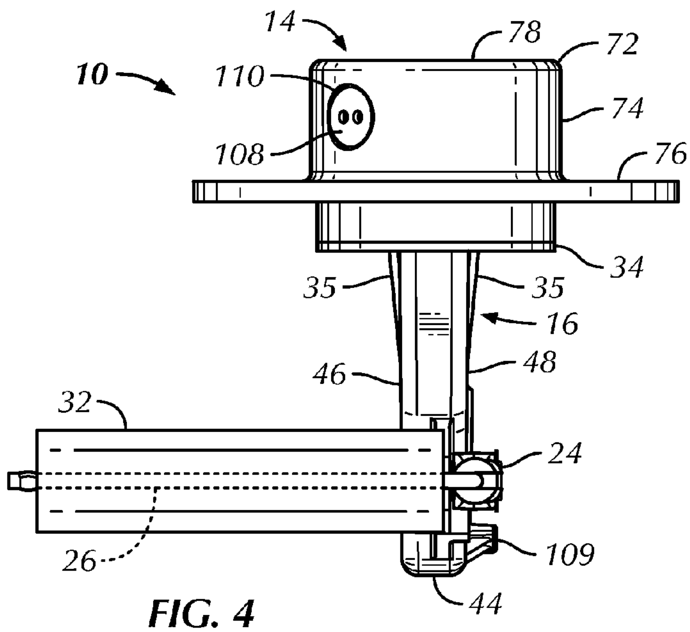
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FIG. 4

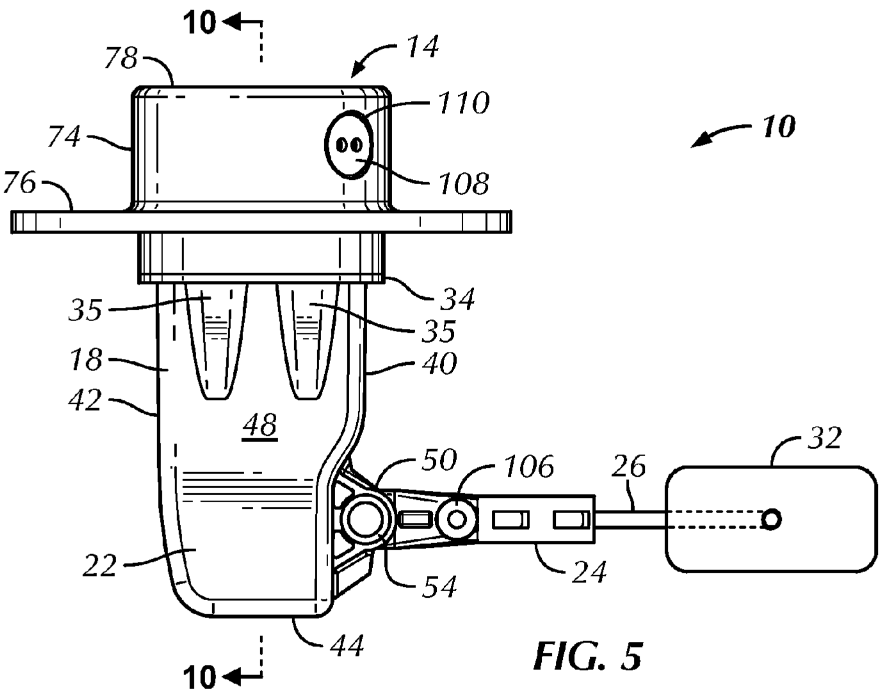
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FIG. 5

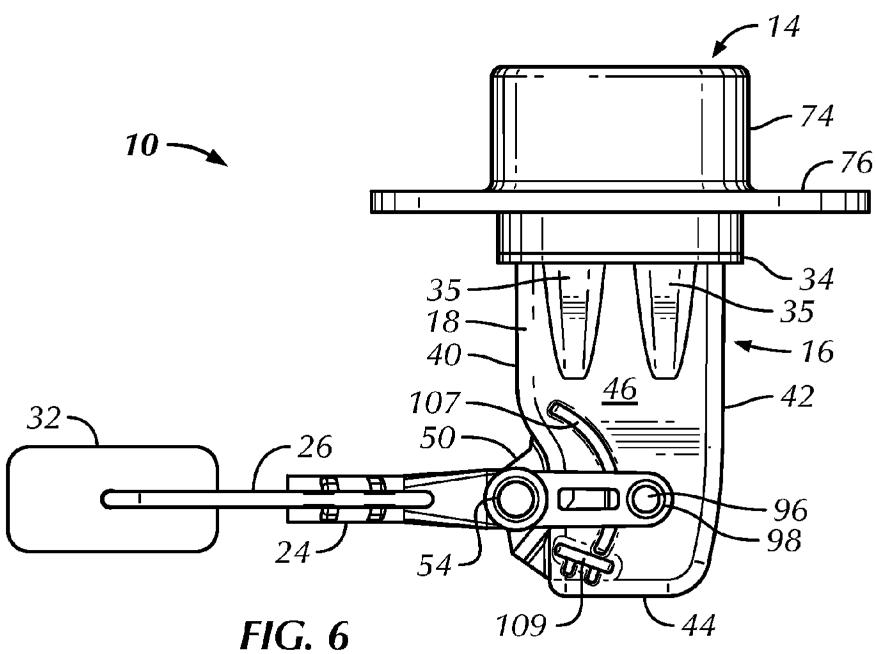
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FIG. 6

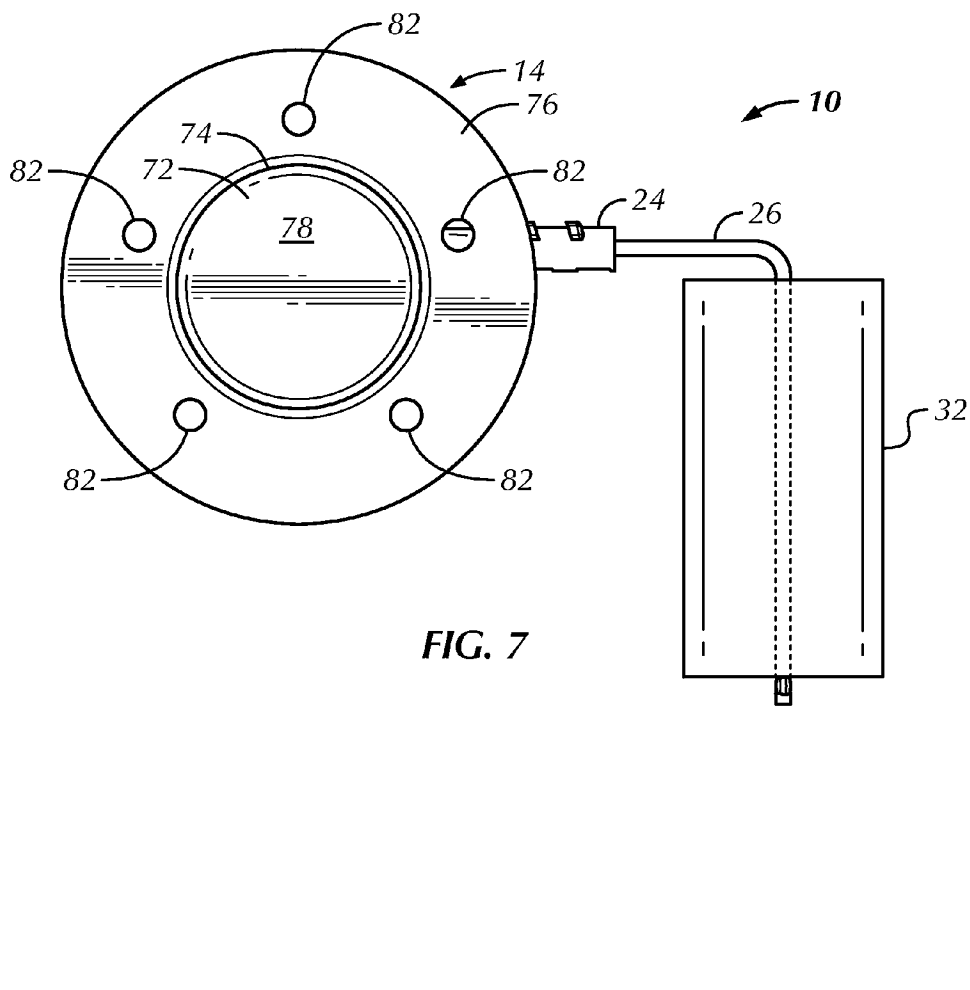

FIG. 7

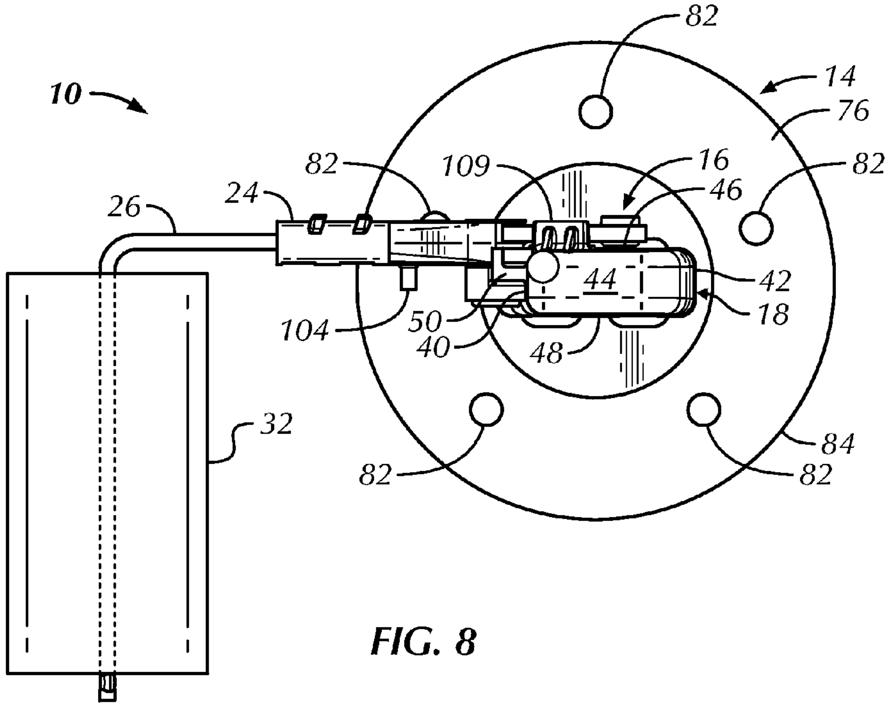

FIG. 8

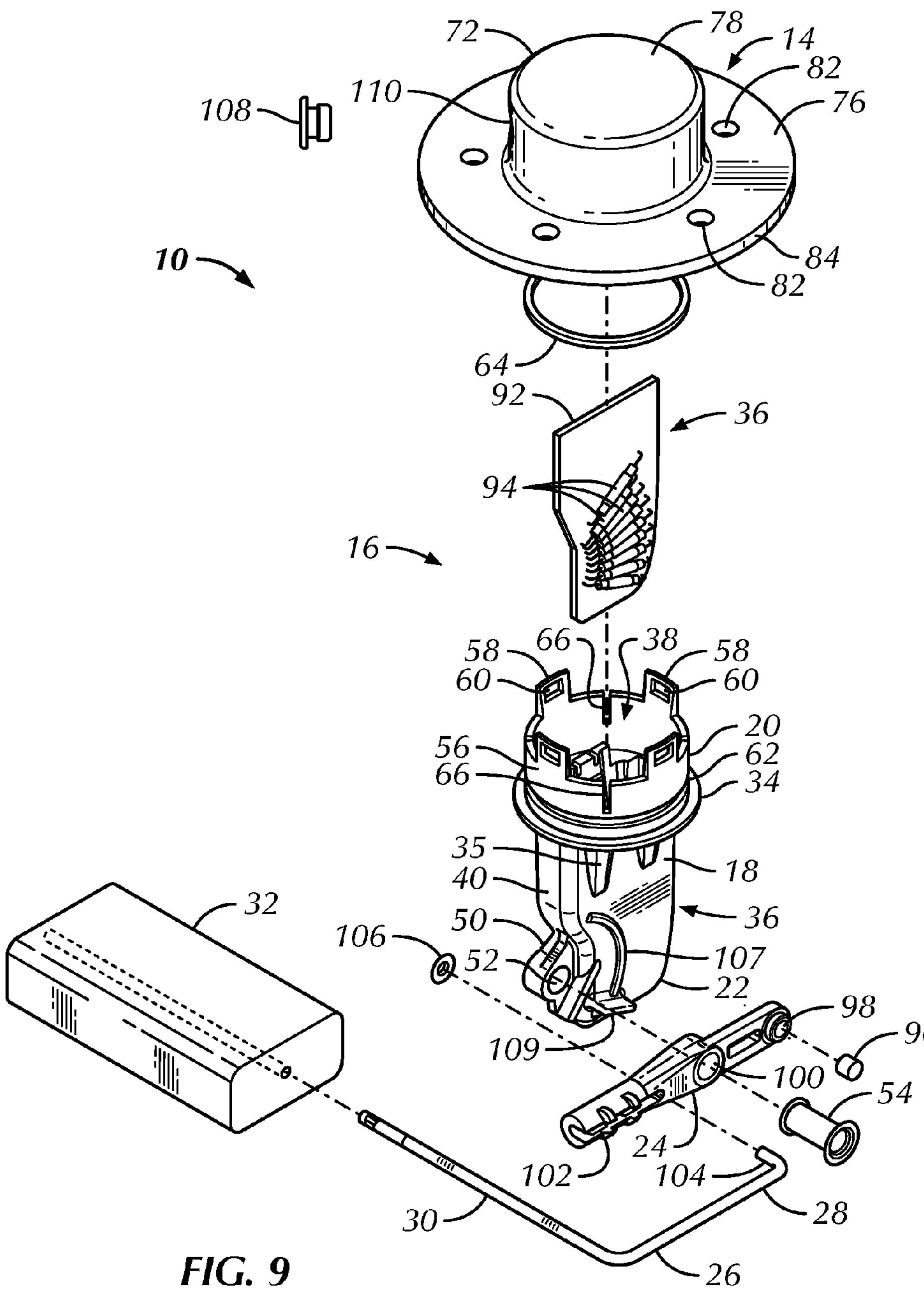

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FIG. 9

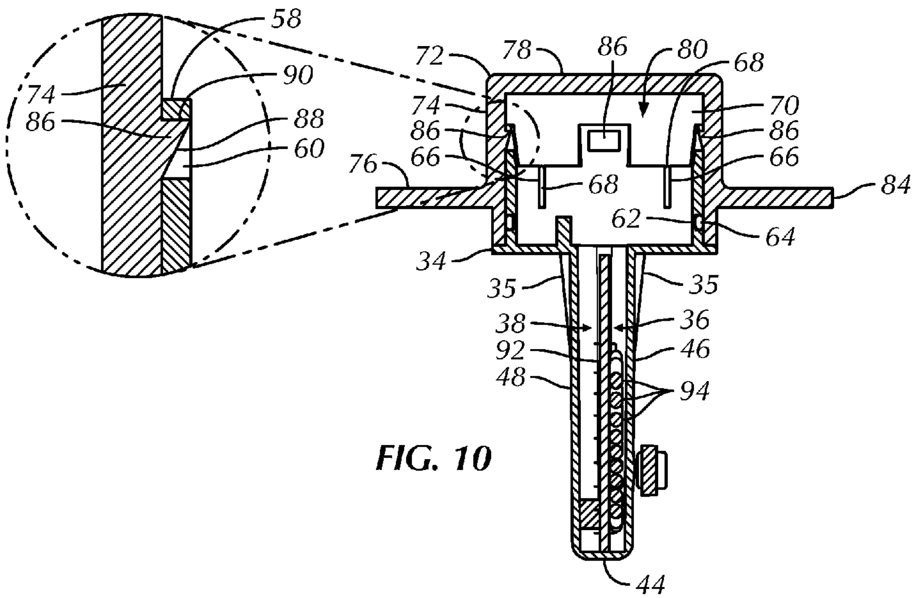
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FIG. 10

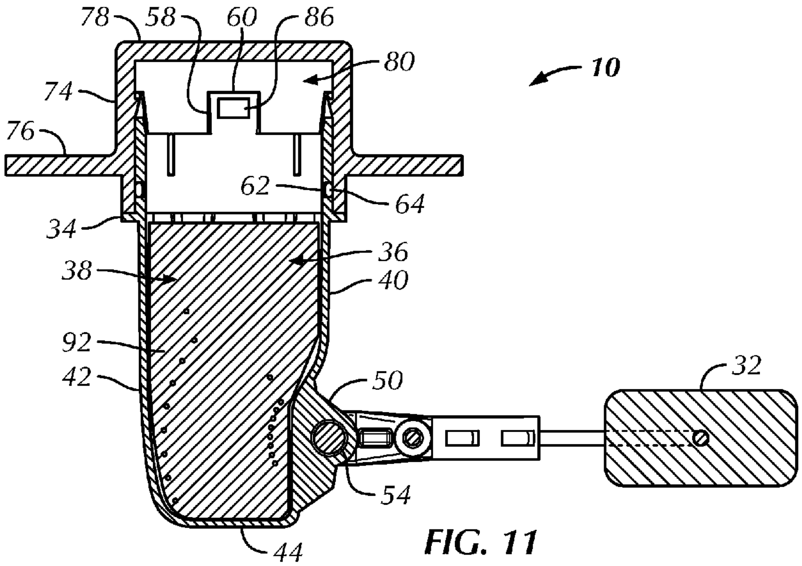
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FIG. 11

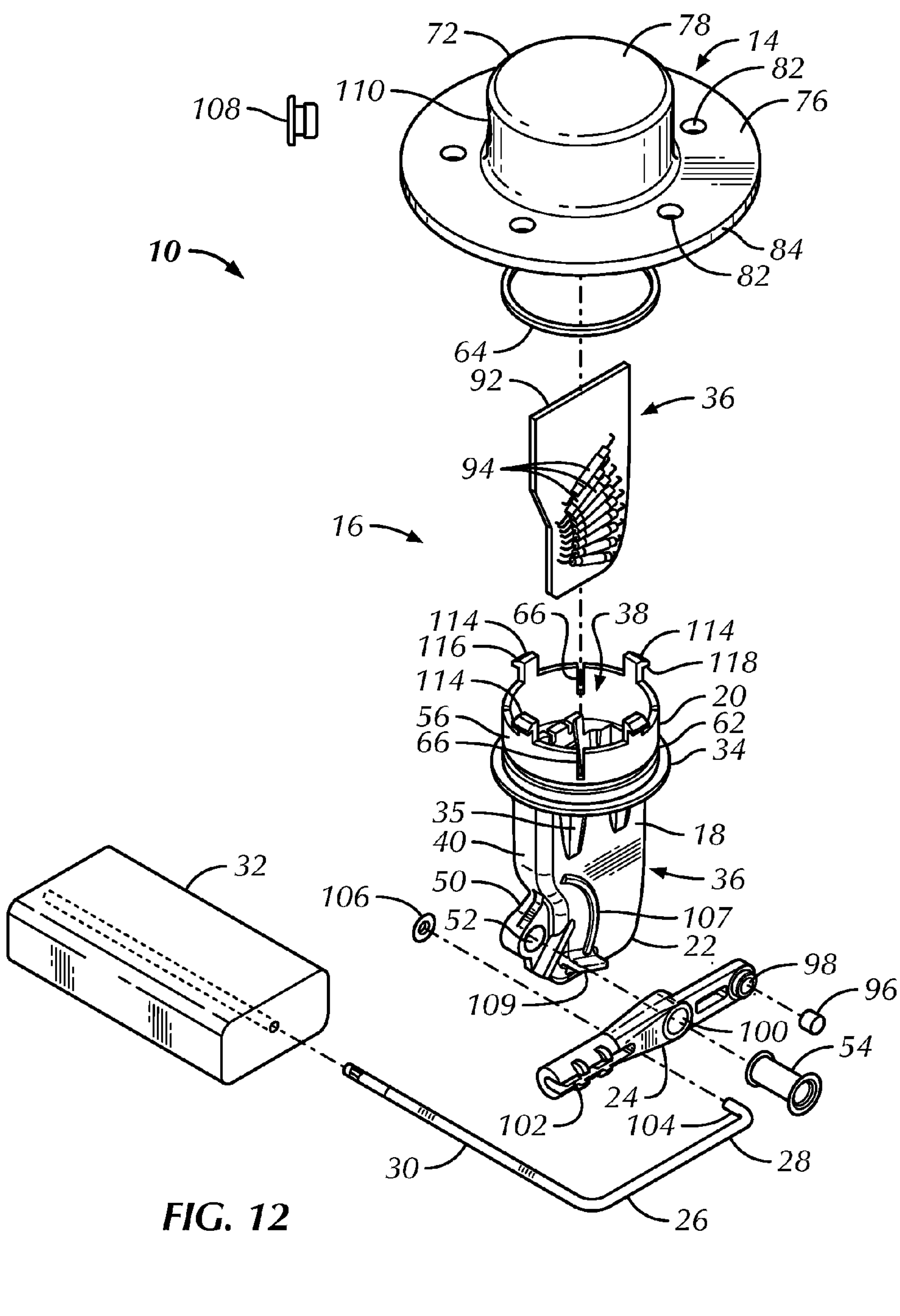
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FIG. 12

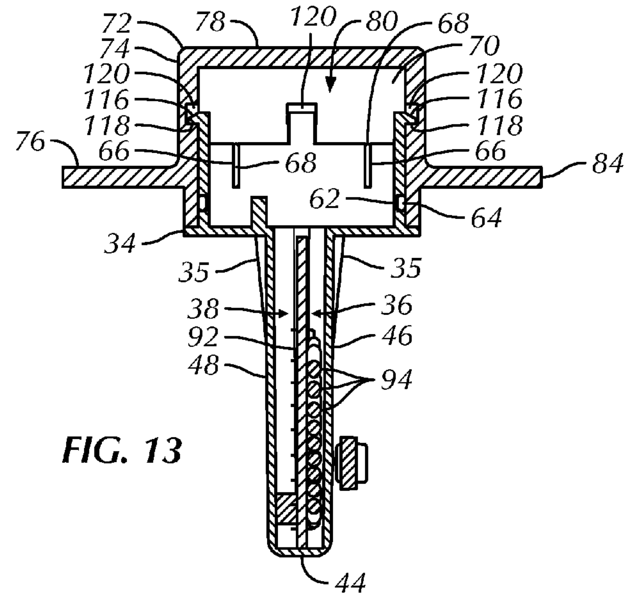
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FIG. 13

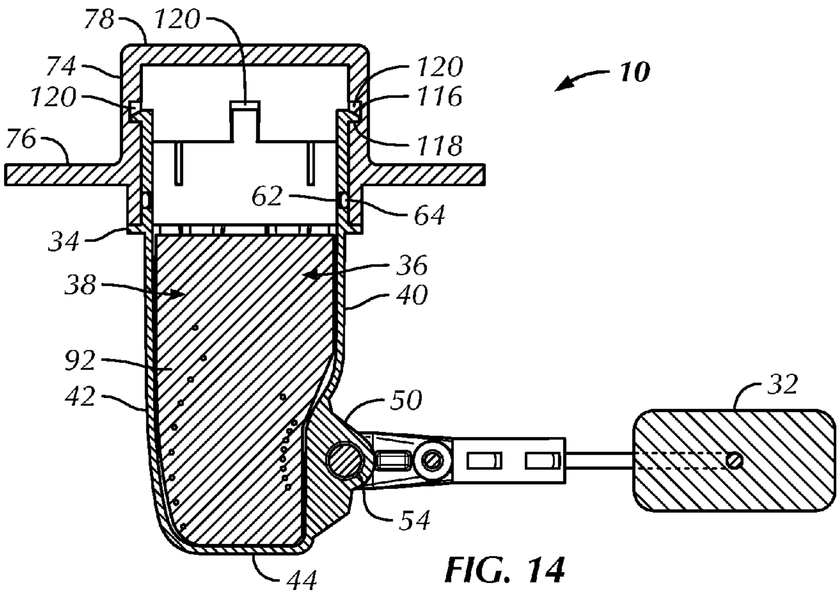
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FIG. 14

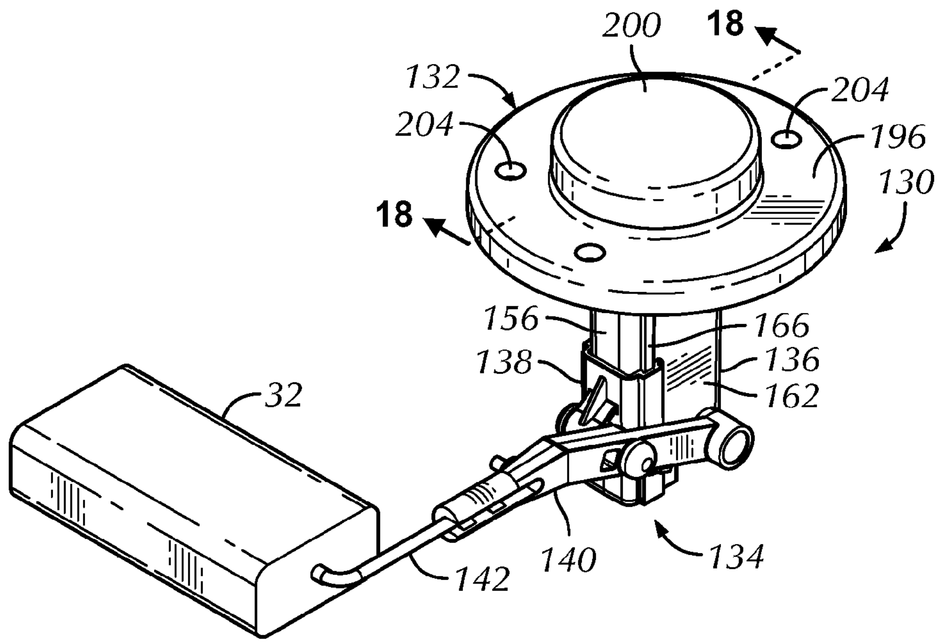
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FIG. 15

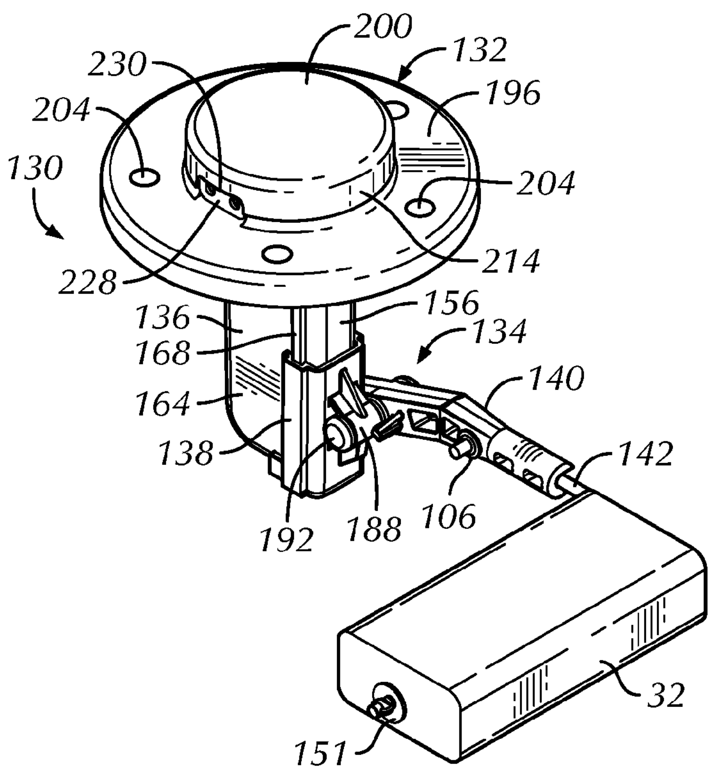
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FIG. 16

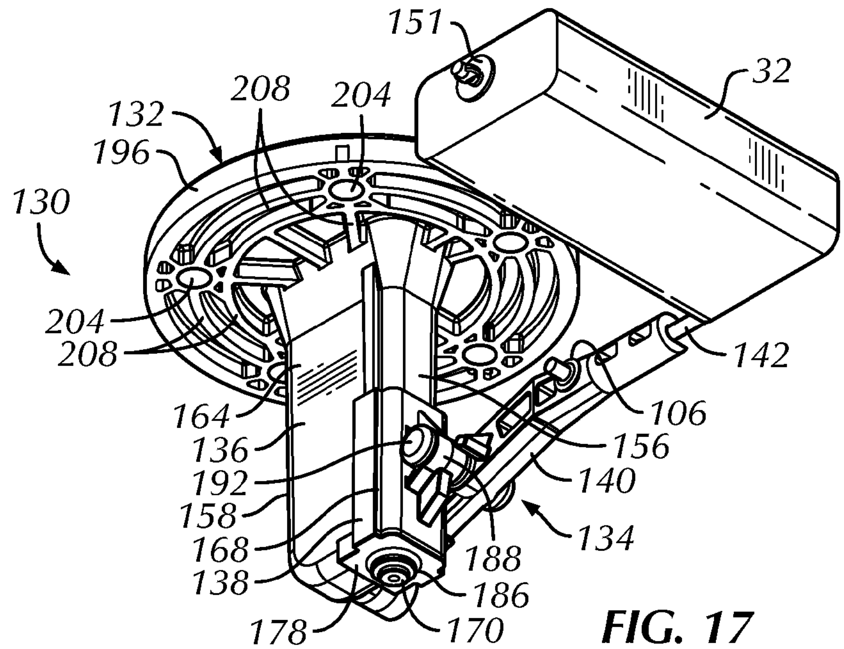
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FIG. 17

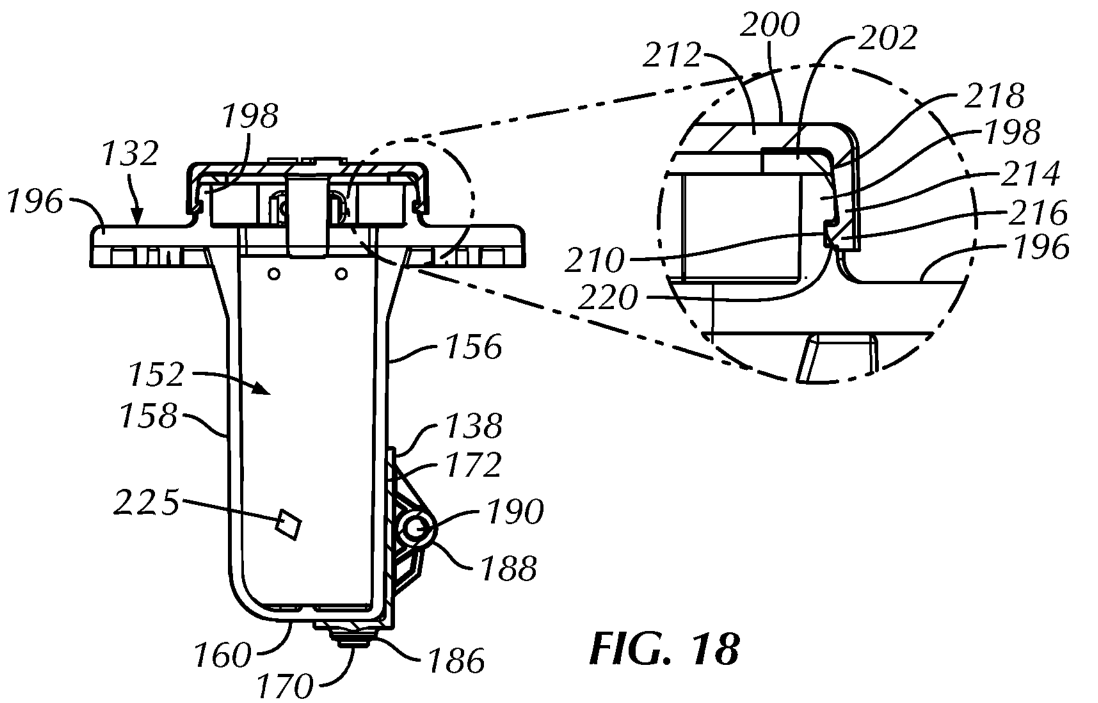
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FIG. 18

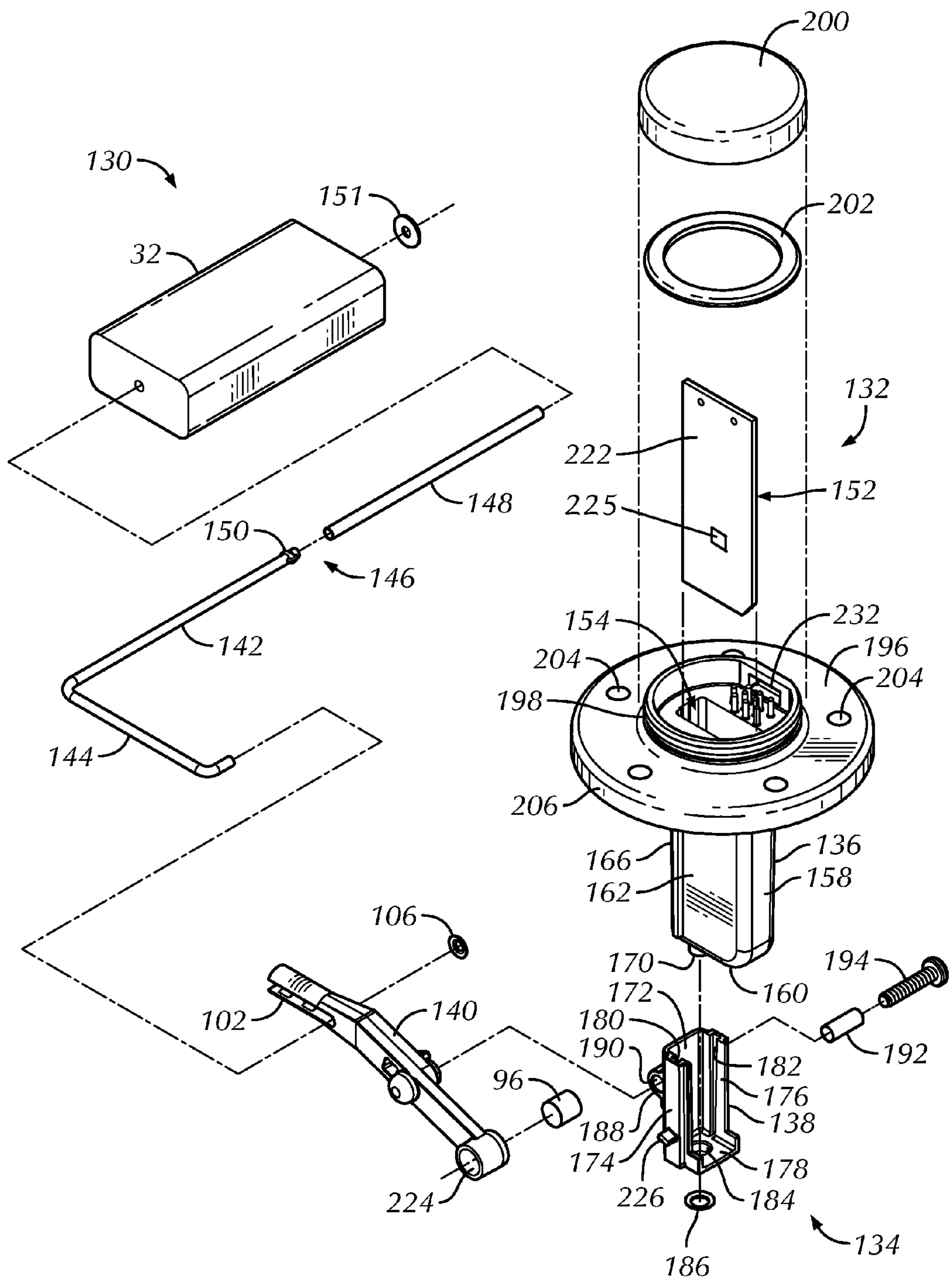
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FIG. 19

LIQUID LEVEL TRANSDUCER WITH ISOLATED SENSOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part (CIP) of U.S. application Ser. No. 13/625,655 filed on Sep. 24, 2012, which is a CIP of U.S. application Ser. No. 13/352,320 filed on Jan. 17, 2012, the disclosures of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] This invention relates to liquid level transducers, and more particularly to a liquid level transducer having a float that moves in response to a change in liquid level.

[0003] Transducers for measuring liquid level are often used in vehicles, industrial equipment, as well as other mobile and stationary systems and components. The electrical output of such transducers varies in response to a change in the liquid level being measured and is typically in the form of a change in resistance, capacitance, current flow, magnetic field, and frequency. These types of transducers may include variable capacitors or resistors, optical components, Hall Effect sensors, strain gauges, ultrasonic devices, reed switch arrays, and so on.

[0004] For reed switch-type devices, a plurality of reed switches are usually arranged in series with a plurality of resistors along the length of a circuit board. The reed switches are normally responsive to the presence and absence of a magnetic field for opening and/or closing the switch. A float rides along the surface of the liquid to be measured and is constrained to move in a linear direction along the circuit board. The float usually includes an embedded magnet to trip one of the reed switches as the float moves in response to a change in liquid level in the tank. Thus, the resistance of the circuit, which is indicative of liquid level, depends on the position of the float and the particular reed switch that has been tripped.

[0005] However, such devices typically have several drawbacks,. For example, it is known that reed switches suffer from hysteresis effects and may open and/or close prematurely depending on the orientation of the reed switches with respect to the magnet, the magnetic strength of the magnet, the distance between the reed switch and the magnet, and so on. When the reed switches are aligned linearly, each reed switch may open and close up to three times as the float approaches, aligns with, and passes each reed switch, thus leading to improper liquid level indication, undesired switching, and premature failure of the switches. In addition, prior art solutions expose the reed switches to the liquid being measured, which may be corrosive and cause inaccurate liquid level readings and premature failure. It would therefore be desirable to overcome at least some of the disadvantages associated with prior art reed switch-type liquid level transducers.

[0006] In addition, prior art liquid level transducers that include a mounting head and an elongate sensor probe, such as a reed switch probe, resistor probe, capacitor probe, and so on, are often difficult and time-consuming to assemble due to the number of individual components and the fastening means associated with each component. It would therefore be desirable to provide a liquid level transducer that is easier to assemble and has relatively fewer parts.

SUMMARY OF THE INVENTION

[0007] In accordance with one aspect of the invention, a transducer for determining the level of liquid within a container includes a mounting head section adapted for connection to the container; a housing section extending from the mounting head section and having vertically oriented side walls adapted for extending into the container, and a hollow interior formed between the side walls, the hollow interior being isolated from liquid within the container; a sensor assembly adapted for location in the container, the sensor assembly having a vertically oriented sensor board located within the hollow interior of the housing section between the side walls; at least one sensor element located on the vertically oriented sensor board within the hollow interior of the housing section; a float rod pivotally connected to the housing section; a float connected to a distal end of the float rod to thereby cause pivoting movement of the float rod in response to a change in liquid level within the container; and an actuator located outside of the housing section and operatively associated with the float rod for pivotal movement therewith, the actuator being operative to change an electrical state of the at least one sensor element to thereby indicate a level condition of the liquid within the container.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The following detailed description of the preferred embodiments of the present invention will be best understood when considered in conjunction with the accompanying drawings, wherein like designations denote like elements throughout the drawings, and wherein:

[0009] FIG. **1** is a right side top isometric view of a liquid level transducer in accordance with the present invention with the float shown in broken line to illustrate the float rod;

[0010] FIG. **2** is a left side top isometric view thereof;

[0011] FIG. **3** is a rear elevational view of the liquid level transducer installed in a container;

[0012] FIG. **4** is a front elevational view thereof;

[0013] FIG. **5** is a right side elevational view thereof;

[0014] FIG. **6** is a left side elevational view thereof;

[0015] FIG. **7** is a top plan view thereof;

[0016] FIG. **8** is a bottom plan view thereof.

[0017] FIG. **9** is a right side top isometric exploded view of the liquid level transducer;

[0018] FIG. **10** is a longitudinal sectional view of the liquid level transducer taken along line **10-10** of FIG. **5** and including an enlarged portion showing the details of a snap-fit assembly;

[0019] FIG. **11** is a longitudinal sectional view of the liquid level transducer taken along line **11-11** of FIG. **3**;

[0020] FIG. **12** is a right side top isometric exploded view of a liquid level transducer in accordance with a further embodiment of the invention;

[0021] FIG. **13** is a longitudinal sectional view similar to FIG. **10** of the liquid level transducer of FIG. **12**;

[0022] FIG. **14** is a longitudinal sectional view similar to FIG. **11** of the liquid level transducer of FIG. **12**;

[0023] FIG. **15** is a right side top isometric view of a liquid level transducer in accordance with a further embodiment of the present invention;

[0024] FIG. **16** is a left side top isometric view thereof;

[0025] FIG. **17** is a left side bottom isometric view thereof;

[0026] FIG. **18** is a longitudinal sectional view of the liquid level transducer taken along line **18-18** of FIG. **16**; and

[0027] FIG. **19** is a left side top isometric exploded view of the liquid level transducer of FIG. **15**.

[0028] It is noted that the drawings are intended to depict only exemplary embodiments of the invention and therefore should not be considered as limiting the scope thereof. It is further noted that the drawings are not necessarily to scale. The invention will now be described in greater detail with reference to the accompanying drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0029] Referring now to the drawings, and to FIGS. **1-8** in particular, a liquid level transducer **10** in accordance with an exemplary embodiment of the present invention is illustrated. The liquid level transducer **10** preferably extends into a container **12** (shown in FIG. **3**), such as a fuel tank, oil reservoir, radiator, brake fluid chamber, or any other container for holding and/or transporting a liquid (not shown) where it is desirous to determine the level of liquid within the container. The transducer **10** preferably includes a mounting head **14** for connection to the container **12** and a sensor assembly **16** installed in the mounting head **14** and extending downwardly therefrom.

[0030] With additional reference to FIGS. **9-11**, the sensor assembly **16** preferably senses liquid level in an arcuate direction as the liquid rises and falls within the container and, in accordance with one preferred embodiment of the invention, includes a housing **18** with an upper housing section **20** that extends into the mounting head **14** and a lower housing section **22** that extends downwardly from the upper section. A rod support **24** is pivotally connected to the lower section **22**. A float rod **26** has a proximal end **28** connected to the float rod support **24** and a distal end **30** that receives a float **32**. As shown, the float rod **26** can be bent to accommodate the float rod mounting and the configuration of a particular tank or container. However, it will be understood that the float rod can be straight or configured in any desired shape to accommodate different liquid level measurement conditions.

[0031] The housing **18** preferably includes a circular flange **34** located between the upper section **20** and lower section **22**. The circular flange **34** preferably abuts or is closely adjacent to a lower end of the mounting head **14** when assembled. Reinforcing ribs **35** are preferably formed on the housing **18**. As shown, the upper housing section **20** is preferably circular in cross-section to receive the mounting head **14** while the lower housing section **22** is preferably rectangular in cross-section to receive a sensor unit **36**. The housing **18** is preferably constructed of a molded material, such as plastic, through injection molding and/or blow molding techniques to form a hollow interior or pocket **38** into which the sensor unit **36** is received. Due to its unitary construction, the hollow interior **38** and its contents are completely isolated from the liquid being measured to advantageously increase the measurement reliability of the transducer **10** and extend its useful life over prior art arrangements where measurement components are directly exposed to the liquid being measured. Since many liquids are corrosive in nature and could cause deterioration of the measurement components and their electrical connections in prior art solutions, isolation of the sensor unit **36** in accordance with the present invention prevents deterioration of both the measurement components as well as their electrical connections, thereby providing a liquid level transducer **10** that is more robust, reliable, and longer lasting than prior art solutions.

[0032] Although it is preferred to construct the housing **18** in the above-described manner, it will be understood that the housing can be formed of two or more pieces and connected together through well-known connecting means such as bonding, welding, and so on, as long as the hollow interior and its contents are isolated from the liquid being measured. It will be further understood that the housing is not limited to plastic material but may be constructed of metal, composites, ceramics, combinations thereof; or any other suitable non-magnetic material. Moreover, although the upper section **20** and lower section **22** of the housing **18** are respectively circular and rectangular in cross section, it will be understood that the housing **18** and its sections can be of any suitable shape without departing from the spirit and scope of the invention.

[0033] The lower section **22** of the housing **18** preferably includes a front wall **40**, a rear wall **42**, a bottom wall **44** extending between the front and rear walls, and side walls **46** and **48** extending laterally between the front and rear walls and upwardly from the bottom wall to the circular flange **34**. A pivot mount **50** is preferably integrally formed with the housing **18** and extends forwardly from the front wall **40**. An opening **52** extends through the pivot mount **50** for receiving a pivot connector **54**. As shown most clearly in FIG. **11**, the pivot mount **50** is preferably solid in cross section and the opening **52** extends through the pivot mount **50** at a location that is spaced from the hollow interior **38**. In this manner, the pivot mount **50** is isolated from the hollow interior to prevent the ingress of liquid therein from the container. In addition, the solid nature of the pivot mount makes it very robust to withstand forces due to the pivoting movement of the float as well as liquid sloshing within the container and other forces related to operation of the transducer **10** when installed in a vehicle, such as acceleration and deceleration forces. Although it is preferred that the pivot mount **50** be spaced from the hollow interior **38**, it will be understood that the pivot mount can be coincident with the hollow interior as long as the housing and pivot mount are constructed to prevent the ingress of liquid into the hollow interior.

[0034] The upper housing section **20** preferably includes a circular wall **56** that extends upwardly from the circular flange **34**. A plurality of connecting members or tabs **58** extend upwardly from the wall **56** and are preferably equally circumferentially spaced around the wall **56**. An aperture **60** extends through each connecting tab **58** and is preferably rectangular in shape. However, it will be understood that the apertures **60** can be of any suitable shape. The tabs **58** are constructed in dimension and material to be somewhat flexible or resilient to receive the mounting head **14** in a snap-fit locking engagement. An annular groove **62** is preferably formed in the outer surface of the wall **56** for receiving an O-ring **64** or the like to seal the housing **18** to the mounting head **14**, as best shown in FIGS. **10** and **11**. In this manner, a seal is created to prevent the ingress of fluid into the housing **18** and mounting head **14** from the tank or other container. One or more alignment slots **66** can be formed in the circular wall **56** for receiving one or more complementary-shaped alignment protrusions **68** (FIGS. **10** and **11**) formed on the inner surface **70** of the mounting head **14** to thereby properly align the mounting head **14** with respect to the housing **18** during assembly.

[0035] The mounting head **14** preferably includes a housing **72** with a circular side wall **74**, a mounting flange **76** extending around the side wall **74**, and an upper wall **78**

terminating the upper end of the circular side wall **74** to form a hollow interior **80**. The mounting head **14** is preferably formed as a unitary structure through injection molding, but may alternatively be formed by machining, die-casting, or other known forming means. The mounting flange **76** is preferably disk-shaped and includes a plurality of mounting holes **82** that extend axially through the mounting flange **76** and in proximity to its outer peripheral edge **84**. The mounting holes **80** are adapted to receive threaded studs (not shown) associated with a tank or other container in a well-known manner. A plurality of connecting members **86** extend generally radially inwardly from the inner surface **70** of the side wall **74**. Each connecting member preferably includes a lower ramped surface **88** that extends upwardly and inwardly from the inner surface **70** and an upper stepped surface **90** that extends between the ramped surface **88** and the inner surface **70**.

[0036] During assembly, the alignment slots **66** of the wall **56** are aligned with the alignment protrusions **68** of the side wall **74**. The mounting head **14** and housing **18** are then pressed together, causing the connecting tabs **58** to slide and flex inwardly along the ramped surface **88** until the apertures **60** clear the connecting members and the tabs **58** snap outwardly onto the upper stepped surface to thereby connect the mounting head **14** to the sensor assembly **16**. Although four connecting tabs and cooperating connecting members are shown, it will be understood that more or less tabs and/or cooperating members can be provided without departing from the spirit and scope of the invention. With this arrangement, and the provision of the O-ring **64**, the hollow interiors of both the mounting head **14** and housing **18** are sealed together and advantageously isolated from the outside environment.

[0037] As best shown in FIGS. **9-11**, the sensor unit **36** preferably includes a sensor board **92**, preferably in the form of a printed circuit board (PCB), located in the hollow interior or pocket **38** of the lower housing section **22**. The PCB preferably extends along a substantial height and width of the interior pocket **38**. A plurality of sensor elements **94**, preferably in the form of normally-open reed switches **94**, are mounted on the PCB **92** and can be connected in series with a plurality of resistors (not shown). The reed switches **94** are preferably oriented in an arcuate pattern, the radial center of which is coaxial with the aperture **52** in the pivot mount **50** of the housing **18**. An actuator **96**, preferably in the form of magnet, is located in an aperture **98** of the rod support **24** for pivoting movement therewith along an arcuate pathway coincident with the arcuate pattern of the reed switches **94**. The pivot connector **54** is preferably in the form of a grommet, rivet, or other circular bearing member and extends through a pivot opening **100** in the rod support **24** and through the aperture **52** in the pivot mount **50** for pivotally connecting the rod support **24** to the housing **18**. The rod support **24** preferably rotates about the pivot connector **54**. Alternatively, the rod support **24** can be fixed with respect to the pivot connector and the pivot connector can rotate with respect to the pivot mount **50**. The proximal end **28** of the float rod **26** is preferably received in an elongate groove **102** formed in the rod support **24** in a snap-fit engagement. An end **104** of the float rod **26** extends through the rod support **24** and receives a locking washer or cap **106** to fix the float rod to the rod support. Although a separate float rod and rod support are shown and described, it will be understood that they can be integrally formed as a unitary component without departing from the spirit and scope of the invention.

[0038] The reed switches **94** are responsive to the magnetic field generated by the magnet **96** which passes through the side wall **46** of the housing **48** as the magnet travels the arcuate pathway in response to float movement due to a change in the level of liquid within the container. When a magnetic field is present on one of the reed switches **94**, the reed switch closes and creates a liquid level signal. As the magnet travels away from the reed switch, it will return to its normally open position and another reed switch will close under the magnetic field. In this manner, liquid level sensing can advantageously occur without exposing the reed switches to the liquid being measured to thereby advantageously increase the measurement reliability of the transducer **10** and extend its useful life over prior art arrangements. An arcuate projection **107** preferably extends outwardly from the side wall **46** to ensure that the magnet **96** and portion of the rod support **24** surrounding the magnet remain at a fixed spaced from the side wall **46** under bending forces or other forces that might be exerted during use, such as acceleration forces, liquid sloshing, and so on. A stop **109** also preferably projects outwardly from the side wall **46** for engaging the rod support **24** to limit movement of the float **32** under full tank and empty tank conditions.

[0039] It will be understood that normally closed reed switches can be used without departing from the spirit and scope of the invention. Although not shown, insulating material, such as potting material, and so on, can be located in the pocket **38**, surrounding the PCB, reed switches, and other components to insulate and protect the components against shock, vibration, and other harsh conditions to which the transducer **10** may be exposed.

[0040] Although a particular number of reed switches are shown, it will be understood that more or less reed switches can be provided without departing from the spirit and scope of the invention. Electrical wires (not shown) preferably extend from the sensor board **92** and through a strain relief or grommet **108** located in an opening **110** of the side wall **74** of the mounting head **14**. Alternatively, the grommet **108** can be in the form of an electrical connector or plug for receiving a complementary connector or plug associated with further processing and/or display circuitry (not shown) of the vehicle or other device with which the container is associated.

[0041] In addition, although reed switches have been described with respect to this embodiment, it will be understood that other magnetic sensing devices can be used without departing from the spirit and scope of the invention. For example, other devices can include, but are not limited to, one or more solid state magnetic flux field sensors, Hall effect sensors, magnetoresistive (MR) sensors, anisotropic MR (AMR) sensors, giant magnetoresistance (GMR) sensors, solid state Micro-Electro-Mechanical Systems (MEMS), magnetic switches, as well as nonmagnetic sensing technologies such as proximity detectors using capacitance, optical, or other measurement technologies, and so on. With the use of the above sensors, it may not be necessary to have the sensor in alignment with the arcuate pathway of the magnet, or a plurality of sensors, since a single Hall effect IC may be sufficient to determine the position of the magnet and thus the level of liquid within the container.

[0042] Likewise, the actuator can be in the form of one or more magnets, LED's, optical fibers or other light source, or other contactless actuator/sensor arrangements to remotely change the electrical state of the sensor elements. In the event that optical sensors are used, the housing can be formed of a material that is translucent or transparent to the wavelength of the light source so that the sensor elements can readily detect movement of the light source as the liquid level in the container rises and falls.

[0043] Referring now to FIGS. **12-14**, a liquid level transducer **112** in accordance with a further embodiment of the invention is illustrated. The liquid level transducer **112** is somewhat similar in construction to the liquid level transducer **10** previously described, with the exception of the manner in which the mounting head **14** is snap-fit onto the housing **18**. As shown, a plurality of hook-shaped connecting members or tabs **114** extend upwardly from the wall **56** of the housing **18** and are preferably equally circumferentially spaced around the wall **56**. Each tab includes a ramped surface **116** and a lower stepped surface **118** that snap-fits into an inner groove or depression **120** formed in the inner surface **70** of the mounting head **14**. It will be understood that the inner depression **120** can be continuous but can alternatively be discrete depressions coincident with the connecting tabs **114** on the housing **118**. As in the previous embodiment, the tabs **114** are constructed in dimension and material to be somewhat flexible or resilient to receive the mounting head **14** in a snap-fit locking engagement.

[0044] During assembly, the alignment slots **66** of the wall **56** are aligned with the alignment protrusions **68** of the side wall **74** and the mounting head **14** and housing **18** are pressed together, causing the connecting tabs **114** to slide and flex inwardly along the ramped surface **116** until the lower stepped surfaces **118** clear the inner groove **120** whereupon the tabs **114** snap outwardly into groove **120** to thereby connect the mounting head **14** to the sensor assembly **16**. Although four connecting tabs and cooperating connecting members are shown, it will be understood that more or less tabs and/or cooperating members can be provided without departing from the spirit and scope of the invention.

[0045] Referring now to FIGS. **15-19**, a liquid level transducer **130** in accordance with another embodiment of the invention is illustrated. The transducer **130** preferably includes a mounting head section **132** for connection a container, such as container **12** (FIG. **3**), and a housing section **136** that supports and contains a sensor assembly **134**.

[0046] The housing section **136** is preferably integrally formed as a unitary structure with the mounting head **132**. A pivot mount **138** is connected to the housing section **136** and a rod support **140** is in turn pivotally connected to the pivot connector **138**. A float rod **142** has a proximal end **144** connected to the rod support **140** and a distal end **146** that receives a float **32**. The distal end **146** of the float rod **142** preferably includes a tubular section **148** that is preferably rotatably mounted onto the float rod **142**. A stop **150** abuts against the end of the tubular section **148** when installed to prevent it from coming loose. The stop **150** can be formed through well-known means such as crimping the float rod, forming a bead on the float rod, affixing a separate component thereto, and the like. The tubular section **148** can be molded with the float **32** using well-known techniques to thereby add structural integrity to the float **32**. In accordance with an alternative embodiment, the tubular section **148** can be inserted into the float **32** after its formation. It will be understood that the float rod **142** can be of multiple-piece construction or single piece construction without departing from the spirit and scope of the invention. As shown, the float rod **142** can be bent to accommodate the configuration of a particular tank or container. However, it will be understood that the float rod can be straight or configured in any desired shape to accommodate different liquid level measurement conditions. A locking washer or cap **151** preferably fits over the distal end of the float rod **142** to retain the float **32** thereon.

[0047] The housing section **136** defines a hollow interior **154** into which a sensor unit **152** is received. The housing section **136** is preferably constructed of a molded material, such as plastic, through injection molding and/or blow molding techniques to form the hollow interior. Due to its unitary construction, the hollow interior **154** and its contents are completely isolated from the liquid being measured to advantageously increase the measurement reliability of the transducer **130** and extend its useful life over prior art arrangements where measurement components are directly exposed to the liquid being measured.

[0048] The housing section **136** preferably includes a front wall **156**, a rear wall **158**, a bottom wall **160** extending between the front and rear walls, and side walls **162** and **164** extending laterally between the front and rear walls and upwardly from the bottom wall to mounting head section **132**. Elongate protrusions or guide members **166** and **168** extend vertically along the side walls **162** and **164**, respectively, adjacent to the front wall **156** and a boss **170** extends downwardly from the bottom wall **160** for receiving the pivot mount **138**.

[0049] The pivot mount **138** preferably includes a front wall **172**, side walls **174**, **176** that extend rearwardly from opposite sides of the front wall **172**, and a bottom wall **178** that extends between the front and side walls. Channels **180** and **182** are formed in the side walls **174** and **176**, respectively, and are sized for receiving the elongate guide members **166** and **168** in sliding engagement when the pivot mount **138** is installed on the housing section **136**. An opening **184** in the bottom wall **178** is sized to receive the boss **170** on the bottom wall **160** of the housing section **136**. A locking collar or push nut **186** is preferably pressed onto the boss **170** after the pivot mount **138** is installed to secure the pivot mount to the housing section **136**. It will be understood that other means for connecting the pivot mount **138** to the housing section **136** can be used, such as adhesive bonding, snap-fitting, press-fitting, welding, and so on, without departing from the spirit and scope of the invention. It will be further understood that the housing section **136** and pivot mount **138** can be formed as a unitary structure. A projection **188** extends forwardly from the front wall **172** and has an aperture **190** formed therein for receiving a bearing sleeve **192** (FIG. **19**) and a threaded fastener **194** that extends through the sleeve **192** and threads into the rod support **140** for pivotally connecting the rod support, and thus the float **32**, to the housing section **136**. Preferably, the aperture **190** extends through the pivot mount **188** at a location that is spaced from the hollow interior **154**. In this manner, the pivot mount **138** is isolated from the hollow interior to prevent the ingress of liquid therein from the container. In addition, the solid nature of the pivot mount makes it very robust to withstand forces due to the pivoting movement of the float as well as liquid sloshing within the container and other forces related to operation of the transducer **130** when installed in a vehicle, such as acceleration and deceleration forces.

[0050] The mounting head section **132** preferably includes a mounting flange **196** with a continuous, circular side wall **198** extending upwardly therefrom and surrounding the hollow interior **154**, a cap **200** connected to the side wall **198** for enclosing the hollow interior **154**, and an annular seal **202**

sandwiched between the cap and the side wall for sealing the hollow interior and its contents from the outside environment.

[0051] The mounting flange **196** is preferably disk-shaped and includes a plurality of mounting holes **204** that extend axially through the mounting flange **196** and in proximity to its outer peripheral edge **206**. The mounting holes **204** are adapted to receive threaded studs (not shown) associated with a tank or other container in a well-known manner. It will be understood that other means for mounting the liquid level transducer **130** to a tank or other container can be used, including NPT type threads, clamping, welding, and so on, without departing from the spirit and scope of the invention. As shown in FIG. **17**, a plurality of reinforcing ribs **208** extend circumferentially around and radially across the mounting flange **196** to strengthen the structure and reduce the amount of material needed and its associated cost.

[0052] As best shown in FIG. **18**, an annular groove **210** is preferably formed in the outer surface of the side wall **198** for receiving the cap **200** in a snap-fit engagement. The cap **200** includes an upper wall **212** and a continuous, circular side wall **214** that extends downwardly from the annular wall. A circular connecting member or tab **216** preferably extends radially inwardly from the side wall **214** to engage the groove **210** in a snap-fit when the cap is pushed onto the continuous, circular side wall **198**. To that end, mutually engageable ramped surfaces **218** and **220** are formed respectively on the side wall **198** and connecting member **216** so that the side wall **214** of the cap expands over the side wall **198** of the mounting flange **196**. It will be understood that the annular groove **210** and the circular connecting member **216** can be formed as two or more discrete sections or segments, as in the previous embodiments, without departing from the spirit and scope of the invention. It will be further understood that the groove and connecting member can be of any suitable shape.

[0053] As best shown in FIGS. **18** and **19**, the sensor unit **152** includes a sensor board **222**, preferably in the form of a printed circuit board (PCB), located in the hollow interior or pocket **154** of the lower housing section **22**. The PCB preferably extends along a substantial height and width of the interior pocket **154**. One or more sensor elements **225** can be mounted on the PCB **222**. The sensor element **225**, as shown in FIG. **18**, has a first position and orientation, while the sensor element **225** in FIG. **19** has a second position and orientation to demonstrate that the present invention is not limited to a particular position on the PCB **222** or orientation. Preferably, the sensor element **225** comprises a Hall effect module or integrated Hall circuit (IC) having a first Hall effect sensor (not shown) in one orientation and a second hall effect sensor (not shown) in another orientation is positioned on a PCB inside the tank. In this manner, the position of the actuator **96**, preferably in the form of a magnet, can be detected. With the sensor element **225** in the form of a Hall effect IC, there is no need to arrange a plurality of sensors along the arcuate pathway of the actuator **96**. In fact, the actuator **96** and Hall effect IC need not be superimposed, but may be offset from each other. In addition, the actuator need not be cylindrical in shape as shown, but may be of other suitable shapes such as rectangular, square, and so on.

[0054] It will be understood that the sensor element **225** is not limited to the Hall effect IC described above, but can include other magnetic sensing elements or devices without departing from the spirit and scope of the invention. For example, other devices can include, but are not limited to, solid state magnetic flux field sensors, magnetoresistive (MR) sensors, anisotropic MR (AMR) sensors, giant magnetoresistance (GMR) sensors, solid state Micro-Electro-Mechanical Systems (MEMS), magnetic switches, as well as nonmagnetic sensing technologies such as proximity detectors using capacitance, optical, or other measurement technologies, and so on.

[0055] Likewise, the actuator can be in the form of one or more magnets, LED's, optical fibers or other light source, or other contactless actuator/sensor arrangements to remotely change the electrical state of the sensor element(s). In the event that one or more optical sensors are used, the housing or a portion of the housing can be formed of a material that is translucent or transparent to the wavelength of the light source so that the sensor element(s) can readily detect movement of the light source as the liquid level in the container rises and falls

[0056] The actuator **96** is located in an aperture **224** of the rod support **140** for pivoting movement therewith along an arcuate pathway. The rod support **140** preferably rotates coaxially with respect to the bearing sleeve **192**. Although a separate float rod and rod support are shown and described, it will be understood that they can be integrally formed as a unitary component without departing from the spirit and scope of the invention.

[0057] The sensor element **225** is responsive to the magnetic field generated by the magnet **96**. The magnetic field passes through the side wall **162** of the housing section **136** as the magnet travels the arcuate pathway in response to float movement due to a change in the level of liquid within the container. In this manner, liquid level sensing can advantageously occur without exposing the sensor element **225** to the liquid being measured to thereby advantageously increase the measurement reliability of the transducer **130** and extend its useful life over prior art arrangements. A stop **226** (FIG. **19**) preferably projects outwardly from the front wall **172** of the pivot mount **138** for engaging the rod support **140** to limit movement of the float **32** when the tank or container is empty.

[0058] It will be understood that reed switches of the previous embodiment can be used without departing from the spirit and scope of the invention. Although not shown, insulating material, such as potting material, and so on, can be located in the hollow interior **154**, surrounding the PCB, sensor element, and other components to insulate and protect the components against shock, vibration, and other harsh conditions to which the transducer **130** may be exposed.

[0059] Although a single sensor element **225** is shown, it will be understood that more sensor elements **225** can be provided without departing from the spirit and scope of the invention. Electrical wires (not shown) preferably extend from the sensor board **222** and through a strain relief or grommet **228** located in an opening **232** of the side wall **198** of the mounting head section **132** and an opening **230** of the side wall **214** of the cap **200**. Alternatively, the grommet **228** can be in the form of an electrical connector or plug for receiving a complementary connector or plug associated with further processing and/or display circuitry (not shown) of the vehicle or other device with which the container is associated.

[0060] It will be understood that the term "preferably" as used throughout the specification refers to one or more exemplary embodiments of the invention and therefore is not to be interpreted in any limiting sense. It will be further understood that the term "connect" and its derivatives refers to two or more parts capable of being attached together either directly or indirectly through one or more intermediate members. In addition, terms of orientation and/or position as may be used throughout the specification denote relative, rather than absolute orientations and/or positions.

[0061] It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof. By way of example, the mounting head is not limited to the flange-type arrangement as shown and described but can be formed with threads or other known mounting means for connecting the transducer to the container without departing from the spirit and scope of the invention. In addition, the sensor elements can be in the form of hall-effect sensors, optical sensors, or the like where direct contact is not required to change an electrical state of the sensor elements. Likewise, the actuator can be in the form of one or more magnets, LED's, optical fibers or other light source, or other contactless actuator/sensor arrangements to remotely change the electrical state of the sensor elements. In the event that optical sensors are used, the housing can be formed of a material that is translucent or transparent to the wavelength of the light source so that the sensor elements can readily detect movement of the light source as the liquid level in the container rises and falls. It will be understood, therefore, that this invention is not limited to the particular embodiments disclosed, but is intended to cover modifications within the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A transducer for determining the level of liquid within a container, the transducer comprising:
- a mounting head section adapted for connection to the container;
- a housing section extending from the mounting head section and having vertically oriented side walls adapted for extending into the container, and a hollow interior formed between the side walls, the hollow interior being isolated from liquid within the container;
- a sensor assembly adapted for location in the container, the sensor assembly comprising:
  - a vertically oriented sensor board located within the hollow interior of the housing section between the side walls;
  - at least one sensor element located on the vertically oriented sensor board within the hollow interior of the housing section;
  - a float rod pivotally connected to the housing section;
  - a float connected to a distal end of the float rod to thereby cause pivoting movement of the float rod in response to a change in liquid level within the container; and
  - an actuator located outside of the housing section and operatively associated with the float rod for pivotal movement therewith, the actuator being operative to change an electrical state of the at least one sensor element to thereby indicate a level condition of the liquid within the container.

2. A transducer according to claim **1**, wherein the mounting head section and housing section are integrally molded as a unitary structure.

3. A transducer according to claim **2**, and further comprising a cap connected to the mounting head section for enclosing the hollow interior.

4. A transducer according to claim **3**, wherein the cap includes an upper wall and a continuous side wall extending downwardly from the upper wall.

5. A transducer according to claim **1**, wherein the at least one sensor element is taken from the group consisting of, solid state magnetic flux field sensors, Hall effect sensors, magnetoresistive (MR) sensors, anisotropic MR (AMR) sensors, giant magnetoresistance (GMR) sensors, solid state Micro-Electro-Mechanical Systems (MEMS), and magnetic switches.

6. A transducer according to claim **6**, wherein the actuator comprises a magnet for changing an electrical state of the at least one sensor element.

7. A transducer according to claim **6**, wherein the at least one sensor element is a Hall effect integrated circuit.

8. A transducer according to claim **6**, wherein the at least one sensor element is a MR sensor.

9. A transducer according to claim **6**, wherein the at least one sensor element is offset from the actuator.

10. A transducer according to claim **6**, and further comprising a rod support pivotally connected to the housing section at the pivot axis, the float rod extending from the rod support on one side of the pivot axis and the magnet being connected to the rod support on an opposite side of the pivot axis for pivoting movement of the magnet along an arcuate pathway.

11. A transducer according to claim **10**, wherein the at least one sensor element is offset from the arcuate pathway of the magnet.

12. A transducer according to claim **11**, and further comprising a sensor board that extends along a substantial height and width of the hollow interior, the at least one sensor element being mounted on the sensor board.

13. A transducer according to claim **1**, and further comprising a sensor board that extends along a substantial height and width of the hollow interior, the at least one sensor element being mounted on the sensor board.

14. A transducer according to claim **13**, wherein the sensor board comprises a printed circuit board.

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